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Original scientific paper

FIRST OVERVIEW OF THE BATRACHOFAUNA AND HERPETOFAUNA OF THE ZELETIN AND VISITOR MOUNTAINS IN MONTENEGRO

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We present the distribution of amphibians and reptiles in the Zeletin and Visitor Mountains in eastern Montenegro based on our field records. Seven amphibian and nine reptile species were recorded at 33 locations between 900 and 2100 *m* a.s.l. The most frequently recorded species were *Ichthyosaura alpestris*, *Rana graeca* and *Lacerta agilis*. Notable records include *Bombina variegata* and *Vipera ursinii*, species of European Community interest. Several threats to batrachofauna and herpetofauna were identified. Our study provides important information for the potential protection of the Zeletin and Visitor Mountains at both national and Natura 2000 levels.

Key words: Amphibians, Reptiles, species diversity, distribution pattern, Balkan Peninsula

INTRODUCTION

With 15 amphibian and 39 reptile species (Jablonski *et al*. 2021, Čađenović *et al*. 2022, Gvozdenović & Iković 2022), Montenegro boasts significant batrachofauna and herpetofauna diversity. The Adriatic coast,

the Zeta River plain, and the area around the capital of Montenegro (Podgorica) are the most species-rich regions of the country (Iković *et al*. 2016, Ljubisavljević *et al*. 2018, Gvozdenović-Nikolić & Iković 2023), while Lake Skadar is even one of the hotspots of diversity of these vertebrate groups on the Balkan Peninsula (Džukić & Kalezić 2004, Crnobrnja-Isailović *et al*. 2018).

Although the pattern of amphibian and reptile diversity in Montenegro largely correlates with the Mediterranean climate, biome heterogeneity, and physiogeographic features, it is also influenced by sampling biases. Consequently, some mountainous areas along the state borders, which are not easily accessible, remain under-recorded (Čađenović 2014, Ljubisavljević *et al*. 2018).

Recent field research under the "Natura 2000" project has aimed to fill data gaps concerning flora, fauna, and habitats, particularly in areas proposed for inclusion in the European network of protected areas. One potential site is the Zeletin and Visitor Mountains in eastern Montenegro, designated as a candidate site of the Emerald Network (MPPUDI 2014). Local spatial plans also suggest it as a future protected landscape or part of the neighbouring regional or national parks (Opština Andrijevica 2016, MTOR 2018).

Despite its natural value, comprehensive surveys of the Zeletin and Visitor Mountains for amphibians and reptiles only began in 2020, under the "Natura 2000" project. Previously, literature contained few amphibian records and no reptile records for these mountains (AZŽS 2012, Džukić *et al*. 2015).

This paper presents results from systematic surveys of amphibians and reptiles in the Zeletin and Visitor Mountains conducted in 2020 and 2021, contributing to knowledge about: (i) the diversity and distribution of these vertebrate groups in Montenegro and the Western Balkans; (ii) the area's biodiversity, which can assist policymakers in its designation as a protected area; (iii) the distribution of key Natura 2000 species.

MATERIAL AND METHODS

Study area

Zeletin and Visitor are high mountains (over 2000 *m*) in the Dinarides range of the Western Balkans, located near the Montenegro-Albania border (Fig. 1). The area is bordered by the Lim River Valley to the south, east, and northeast, and the Kutska River to the west. It features rich surface waters, including Visitorsko Lake, Lake Bješkeća (Kamena), numerous rivers, intermittent streams, springs, and ponds. The mountains consist of

Paleozoic shales with volcanic rocks and limestone at higher elevations. Beech forests dominate the foothills, gradually mixing with coniferous species (*Abies alba*, *Picea abies*, *Pinus sylvestris*). Endemic/subendemic conifers of the Balkan Peninsula (*Pinus peuce* and *Pinus heldreichii*) grow at higher altitudes, while *Pinus mugo* is found at the alpine tree line. The highest elevations feature alpine meadows and pastures, rocky outcrops, and cliffs (Rubinič *et al*. 2019). The area is characterized by an alpine climate with long, cold, snowy winters and short, humid and fresh summers, with winds from the west and south bringing precipitation in spring and fall (Milojević 1935).

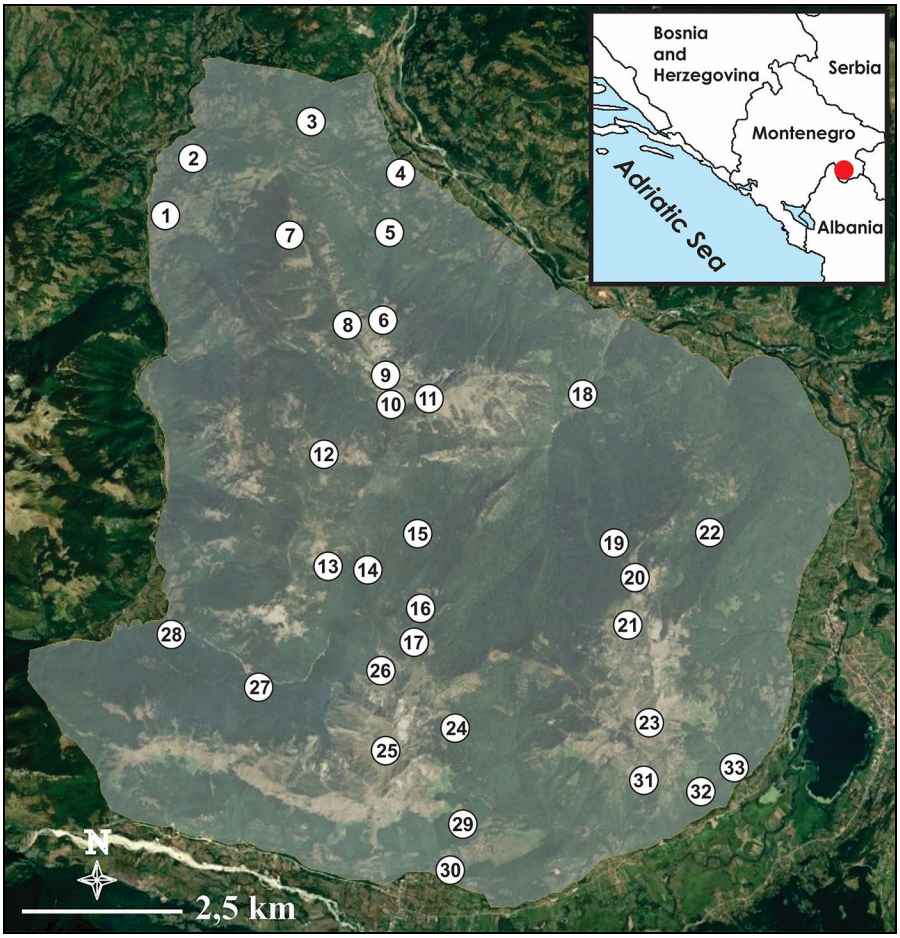

Fig. 1. – Distribution of records of amphibians and reptiles in the Visitor and Zeletin Mountains (transparent area). The location numbers are explained in the Tables 1–2 and in the Supplementary Information. The background map was adapted from Google Earth Pro®. The inset map shows the position of the Visitor and Zeletin Mountains (red dot) in a broader area.

Methods

Data on amphibians and reptiles in the Zeletin and Visitor Mountains were collected during fieldwork in the first half of august 2020 and 2021 as part of two research projects (see Acknowledgements). Surveys were conducted on favourable weather days (i.e., sunny without rain or strong winds) by walked transects using visual searches, dip netting, inspection of cover objects (logs, bark, rocks) as potential shelter sites and detection of roadkill. Species were identified following Speybroeck *et al*. (2016). After identification, the captured specimens were released at their capture sites, and all cover was returned to its original position. Taxonomy and nomenclature followed Speybroeck *et al*. (2020) and Jablonski *et al*. (2021). Chorotypes were determined based on Vigna Taglianti *et al*. (1999).

RESULTS

Seven amphibian and nine reptile species were recorded during surveys (Tables 1 and 2). Records were made at 33 locations between 900 and 2100 *m* a.s.l. (Fig. 1, Supplementary Information). *Salamandra salamandra, Rana graeca, Rana temporaria* and *Rana dalmatina* were found around streams and springs up to 1500–1700 *m*, while *Ichthyosaura alpestris* was found only above 1700 *m* in ponds, lakes, and springs. *Bombina variegata* and *Bufo bufo* occupied wider altitude ranges. *B. variegata* was found in small water bodies up to 1900 *m*, while *B. bufo* tadpoles were found in ponds and slower parts of streams and springs up to 2100 *m*. Most reptile species (*Lacerta agilis, Coronella austriaca, Natrix natrix, Vipera berus* and *Vipera ursinii*) were found above 1700 *m*, while others (*Lacerta viridis, Podarcis muralis* and *Zamenis longissimus*) occurred in the zone of deciduous and mixed forests up to 1500 *m*. *Anguis fragilis* inhabited the widest range of altitudes from the foothills up to 2000 *m*.

Reptiles were found at more sites than amphibians (29 vs. 22). The most frequently recorded amphibians were *I. alpestris* and *R. graeca* (eight sites each), while the most common reptile was *L. agilis* (15 sites). The rarest species were *R. dalmatina* and *C. austriaca*, observed at a single site each.

A maximum of four species per site were recorded at some locations at the foothills of the Zeletin mountain (No. 1. Cecune, No. 27. Katun Savovića), at high open grass and rocky sites with springs or ponds (No. 10. Gropa, No. 25. Greben) or on the highest mountain ridges (No. 8. Goveđak, No. 9. Rogovi) inhabited by the reptiles on open rocky ground above the tree line.

Table 1. – Amphibian species recorded in the area of Zeletin and Visitor Mountains. Locality numbers and names correspond to those in Supplementary Information and Fig. 1. (+) our field data; (*) literature data; (+*) literature and our field data. Literature sources: AZŽS 2012, Džukić *et al*. 2015.

No	Locality	*Salamandra salamandra*	*Ichthyosaura alpestris*	*Bombina variegata*	*Bufo bufo*	*Rana temporaria*	*Rana dalmatina*	*Rana graeca*
1	Zeletin Mt.: Cecune			+		+		
2	Zeletin Mt.: Krnjač			+				
3	Zeletin Mt.: Osoja	+						
4	Zeletin Mt.: Ulotina							+
5	Zeletin Mt.: Pasuljište							+
6	Zeletin Mt.: Katunište							+
7	Zeletin Mt.: Luški katun		+		+			
10	Zeletin Mt.: Gropa		+					
12	Zeletin Mt.: Ćeransko		+	+				
14	Visitor Mt.: Misa		+					
15	Visitor Mt.: Nenova Gora			+		+		+
17	Visitor Mt.: Lake Kamena (Bješkeća)		+*					
18	Visitor Mt.: Kletovnica							+
19	Visitor Mt.: Visitorsko Lake		+*					+
20	Visitor Mt.: Katun Mramorje				+			
22	Visitor Mt.: Kupušnjaci							+
24	Visitor Mt.: Valje				+			
25	Visitor Mt.: Greben		+		+			
26	Visitor Mt.: Duljov katun		+	+				
27	Visitor Mt.: Katun Savovića				+			+
28	Zeletin Mt.: Kuti	+						
31	Visitor Mt.: Ormoljišta	+					+	
	Visitor Mt: without precise locality	*						

The most common chorotype was South-European, represented by four amphibian and four reptile species, most found up to 1700 *m*. The European and Euro-Siberian chorotypes were mainly found above this altitude. The rarest chorotypes were Europeo-Mediterranean and Central-asiatic-Europeo-Mediterranean, each represented by one species (Table 3).

S. salamandra and *V. ursinii* are threatened species (VU), while other recorded species are non-threatened according to the global IUCN categorization. According to the national IUCN categorization, *V. ursinii* is also classified as vulnerable, while *I. alpestris* is near threatened (NT) (Table 3). Both *V. ursinii* and *B. variegata* are listed in Annex II of the Habitats Directive, making them target species of the Natura 2000 ecological network.

Table 2. – Reptile species recorded in the area of Zeletin and Visitor Mountains. Locality numbers and names correspond to those in Supplementary Information and Fig. 1. (+) our field data.

No	Locality	*Lacerta agilis*	*Lacerta viridis*	*Podarcis muralis*	*Anguis fragilis*	*Zamenis longissimus*	*Coronella austriaca*	*Natrix natrix*	*Vipera berus*	*Vipera ursinii*
1	Zeletin Mt.: Cecune			+	+					
2	Zeletin Mt.: Krnjač			+						
3	Zeletin Mt.: Osoja			+						
4	Zeletin Mt.: Ulotina		+			+				
6	Zeletin Mt.: Katunište	+							+	
7	Zeletin Mt.: Luški katun	+								
8	Zeletin Mt.: Goveđak	+			+				+	+
9	Zeletin Mt.: Rogovi	+			+		+		+	
10	Zeletin Mt.: Gropa	+						+		+
11	Zeletin Mt.: Plana	+								+
12	Zeletin Mt.: Ćeransko	+								
13	Zeletin Mt.: Izvori	+								
14	Visitor Mt.: Misa	+						+		
16	Visitor Mt.: Tatarija	+								
17	Visitor Mt.: Lake Kamena (Bješkeća)							+		
18	Visitor Mt.: Kletovnica			+						
19	Visitor Mt.: Visitorsko Lake							+		
20	Visitor Mt.: Katun Mramorje	+								
21	Visitor Mt.: Visitorske livade	+							+	+
23	Visitor Mt.: Plane	+							+	+
25	Visitor Mt.: Greben	+								+
26	Visitor Mt.: Duljov katun	+								
27	Visitor Mt.: Katun Savovića			+		+				
28	Zeletin Mt.: Kuti		+	+						
29	Zeletin Mt.: Strane			+						
30	Visitor Mt.: Zagrađe					+				
31	Visitor Mt.: Ormoljišta			+						
32	Visitor Mt.: Kodra Ujkova			+		+				
33	Visitor Mt.: Gropa Smajlova		+	+						

Table 3. – The list of amphibian and reptile species recorded in the area of Zeletin and Visitor Mountains, with chorotype classification, international and national conservation statuses and protection legislative. The global IUCN category is given according to IUCN (2024), the national IUCN category according to Jelić *et al.* 2023 and the national protection status according to Republički zavod za zaštitu prirode Crne Gore (2006).

Species	Chorotype	Global IUCN category	National IUCN category	Habitats Directive (Annex)	Bern Convention (Appendix)	CITES (Appendix)	National protection status
Amphibians							
Salamandra salamandra	S-European	VU	LC	/	III	/	+
Ichthyosaura alpestris	European	LC	NT	/	III	/	+
Bombina variegata	S-European	LC	LC	II, IV	II	/	/
Bufo bufo	Europeo-Mediterranean	LC	LC	/	III	/	+
Rana temporaria	European	LC	LC	V	III	/	/
Rana dalmatina	S-European	LC	LC	IV	II	/	/
Rana graeca	S-European	LC	LC	IV	III	/	+
Reptiles							
Lacerta agilis	Euro-Siberian	LC	LC	IV	II	/	+
Lacerta viridis	S-European	LC	LC	IV	II	/	+
Podarcis muralis	S-European	LC	LC	IV	II	/	+
Anguis fragilis	European	LC	LC	/	III	/	+
Zamenis longissimus	S-European	LC	LC	IV	II	/	+
Coronella austriaca	European	LC	LC	IV	II	/	+
Natrix natrix	Centralasiatic-Europeo-Mediterranean	LC	LC	/	III	/	+
Vipera berus	Euro-Siberian	LC	LC	/	III	/	/
Vipera ursinii	S-European	VU	VU	II, IV	II	I	/

DISCUSSION

The recorded amphibian and reptile species in the Visitor and Zeletin Mountains comprise about 47% and 23% of the total batrachofauna and herpetofauna diversity of Montenegro, respectively (Jablonski *et al*. 2021,

Čađenović *et al*. 2022, Gvozdenović & Iković 2022). A lower diversity, particularly of reptiles, compared to the national territory or southern parts of Montenegro with heterogeneous topography and more favourable climatic conditions, was expected (Crnobrnja-Isailović *et al*. 2018, Gvozdenović-Nikolić & Iković 2023), as the studied area is spatially limited and restricted to higher altitudes. The number of amphibian and/or reptile species in the Zeletin and Visitor Mountains is similar to other mountainous regions of Montenegro studied (Bjelasica Mt., eastern Montenegro – Tomović *et al*. 2004; Krnovo plateau, central Montenegro – Polović & Čađenović 2013; Ljubišnja Mt., north-western Montenegro – Polović & Čađenović 2014), but lower than the Durmitor massif in northern Montenegro (Džukić 1991). It should be noted, however, that the Durmitor study also included mid-altitude records from gorges and canyons, which served as corridors for the dispersal of Mediterranean faunal elements (e.g. Tomović *et al*. 2000, Crnobrnja-Isailović *et al*. 2020).

With few previous records for *S. salamandra* and *I. alpestris* in the Visitor Mountain (see Table 1), this study significantly enhances the understanding of amphibian and reptile spatial patterns in eastern Montenegro, addressing distribution data gaps in border areas.

Amphibian and reptile occurrence in the Zeletin and Visitor Mountains reflects the distribution and availability of preferred habitats. For instance, *N. natrix* was found above 1700 *m* in plateau ponds and lakes, which also serve as breeding sites for *B. bufo* and *I. alpestris*, while *R. graeca* was found near fast-flowing streams that run down mountain slopes. Reptiles of the higher elevations in the southern Balkans, such as *L. agilis, C. austriaca, V. berus* and *V. ursinii*, were found on alpine meadows and grassy rocky slopes within coniferous forest zone or above the tree line.

The Zeletin and Visitor Mountains still feature well-preserved habitats for several species important for conservation at national and/or international level (e.g., *S. salamandra, I. alpestris, B. variegata* and *V. ursinii*). However, several threats, including forest fires, logging, small hydropower plants (SHPPs), and afforestation of alpine grasslands and ponds, were identified during fieldwork (Fig. 2).

Species associated with forests or edges face threats from illegal logging and forest fires (Cox *et al*. 2022, Iglesias‐Carrasco *et al*. 2023), while SHPPs negatively impact species relying on lotic aquatic ecosystems (*R. graeca*, *S. salamandra*, *B. variegata*, *B. bufo* and *R. temporaria*) or humid terrestrial habitats (*V. berus*) (Crnobrnja-Isailović *et al*. 2021). Abandonment of traditional farming practices, such as extensive grazing, is leading to the overgrowth of grasslands and aquatic habitats in higher parts of the Visitor and Zeletin Mountains. Conservation of open and mosaic-like

habitats is crucial for *L. agilis* and *V. ursinii* (Edgar & Bird 2006, Mizsei *et al*. 2023), while pond conservation is vital for *I. alpestris*.

Fig. 2. Threats affecting amphibians and reptiles identified in the study area: forest fires (a), logging (b), afforestation of ponds (c), afforestation of alpine grasslands (d), the Šeremet stream before (e) and after the installation of a small hydropower plant (f).

Spatial planning for this area should be conducted carefully, as excessive urbanization and tourism infrastructure could exacerbate existing threats, such as deforestation and fires, and also cause habitat fragmentation, pollution, and fish introductions into small aquatic habitats. Fish introductions have been shown to be the main determinant of decline or extirpation of paedomorphic and/or metamorphic *I. alpestris* in many small lentic freshwater habitats, such as ponds and mountain lakes in Montenegro

(Denoël *et al*. 2019). Although Montenegro banned further SHPP construction three years ago (RERI 2021), stricter controls on illegal logging and forest fire prevention are needed. If the Visitor and Zeletin Mountains are declared protected, it is imperative to address these threats adequately and manage tourism sustainably.

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Supplementary Information

Details of the localities as follows: locality number, locality name, coordinates, altitude. The locality numbers correspond to those in Tables 1 and 2.

1. Zeletin Mt: Cecune, 42.6770 N, 19.7881 E, 990 *m*; 2. Zeletin Mt: Krnjač, 42.6857 N, 19.7945 E, 1107 *m*; 3. Zeletin Mt: Osoja, 42.6908 N, 19.8191 E, 1266; 4. Zeletin Mt: Ulotina, 42.6854 N, 19.8394 E, 875 *m*; 5. Zeletin Mt: Pasuljište, 42.6737 N, 19.8352 E, 1218 *m*; 6. Zeletin Mt: Katunište, 42.6592 N, 19.8343 E, 1715 *m*; 7. Zeletin Mt: Luški katun, 42.6720 N, 19.8158 E, 1820 *m*; 8. Zeletin Mt: Goveđak, 42.6581 N, 19.8276 E, 2025 *m*; 9. Zeletin Mt: Rogovi, 42.6509 N, 19.8350 E, 1950 *m*; 10. Zeletin Mt: Gropa, 42.6470 N, 19.8356 E, 1896 *m*; 11. Zeletin Mt: Plana, 42.6475 N, 19.8435 E, 2096 *m*; 12. Zeletin Mt: Ćeransko, 42.6390 N, 19.8223 E, 1817 *m*; 13. Zeletin Mt: Izvori, 42.6230 N, 19.8234 E, 1856 *m*; 14. Visitor Mt: Misa, 42.6222 N, 19.8310 E, 1914 *m*; 15. Visitor Mt: Nenova Gora, 42.6277 N, 19.8408 E, 1633 *m*; 16. Visitor Mt: Tatarija, 42.6164 N, 19.8413 E, 1884 *m*; 17. Visitor Mt: Lake Kamena (Bješkeća), 42.6121 N, 19.8405 E, 1942 *m*; 18. Visitor Mt: Kletovnica, 42.6488 N, 19.8756 E, 920 *m*; 19. Visitor Mt: Visitorsko Lake, 42.6256 N, 19.8796 E, 1745 *m*; 20. Visitor Mt: Katun Mramorje, 42.6210 N, 19.8836 E, 1910 *m*; 21. Visitor Mt: Visitorske livade, 42.6142 N, 19.8818 E, 1937 *m*; 22. Visitor Mt: Kupušnjaci, 42.6273 N, 19.8990 E, 1430 *m*; 23. Visitor Mt: Plane, 42.6001 N, 19.8854 E, 2065 *m*; 24. Visitor Mt: Valje, 42.5998 N,

19.8474 E, 1714 *m*; 25. Visitor Mt: Greben, 42.5967 N, 19.8343 E, 2057 *m*; 26. Visitor Mt: Duljov katun, 42.6083 N, 19.8336 E, 1858 *m*; 27. Zeletin Mt: Katun Savovića, 42.60536 N, 19.8087 E, 1302 *m*; 28. Zeletin Mt: Kuti, 42.6133 N, 19.7902 E, 1086 *m*; 29. Visitor Mt: Strane, 42.5858 N, 19.8492 E, 1500 *m*; 30. Visitor Mt: Zagrađe, 42.5773 N, 19.8468 E, 1133 *m*; 31. Visitor Mt: Ormoljišta, 42.5920 N, 19.8847 E, 1561 *m*; 32. Visitor Mt: Kodra Ujkova, 42.5896 N, 19.8964 E, 1291 *m*; 33. Visitor Mt: Gropa Smajlova, 42.5919 N, 19.9046 E, 1053 *m*.

ПРВИ ПРЕГЛЕД БАТРАХОФАУНЕ И ХЕРПЕТОФАУНЕ ПЛАНИНА ЗЕЛЕТИН И ВИСИТОР У ЦРНОЈ ГОРИ

КАТАРИНА ЉУБИСАВЉЕВИЋ, СЛАЂАНА ГВОЗДЕНОВИЋ-НИКОЛИЋ, ВУК ИКОВИЋ

РЕЗИМЕ

Представљамо распрострањење водоземаца и гмизаваца на планинама Зелетин и Виситор у источној Црној Гори на основу наших теренских података. На 33 локације између 900 и 2100 м надморске висине забележено је седам врста водоземаца и девет врста гмизаваца. Најчешће забележене врсте су *Ichthyosaura alpestris*, *Rana graeca* и *Lacerta agilis*. Значајни налази укључују врсте *Bombina variegata* и *Vipera ursinii*, врсте од интереса за Европску заједницу. Идентификовано је неколико врста претњи по батрахофауну и херпетофауну. Наша студија пружа важне информације за потенцијалну заштиту планина Зелетин и Виситор на националном и на нивоу еколошке мреже „Натура 2000“.

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CHARACTERISTICS OF A MIXED COLONY OF BEE-EATERS, STARLINGS AND SWIFTS WITHIN THE PROTECTED HABITAT "GLINARA", BELGRADE, SERBIA

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We examined the characteristics of a colony of European Bee-eaters (*Merops apiaster*), Common Starlings (*Sturnus vulgaris*), and Common Swifts (*Apus apus*) in a loess bank located within the Protected habitat "Glinara", Belgrade, Serbia. Using video observations recorded during the 2023 breeding season, we documented 305 active bee-eater nests, 127 starling nests, and 13 swift nests. Bee-eaters and starlings placed significantly more nests in the top and mid portions of the bank compared to the bottom portion, while swift nests were exclusively recorded in the mid and top portions of the bank.

Keywords: cavity-nesters; nest position, *Merops apiaster*, *Sturnus vulgaris*, *Apus apus*

INTRODUCTION

Coloniality is widespread among avian taxa (Rolland *et al*. 1998) and is characterized by the breeding of varying numbers of individuals in a typically centralized location at the same time (Brown & Brown 2001). Although various factors may drive the evolution of colonial breeding in birds, three are considered the most influential: (1) the limitation of suitable nesting sites; (2) antipredator benefits, including collective detection of predators, the dilution effect, confusion of predators, or group defense; and (3) foraging benefits, as individuals may locate food patches more quickly by observing their colony mates (Brown & Brown 2001). These factors can lead to the aggregation of birds from different species and the formation of mixed-species colonies (Burger 1981, Goodale *et al*. 2017). Additionally, members of one species, through their activities (e.g., nest construction), may create breeding habitats for other species, further facilitating the development of mixed-species colonies (Goodale *et al*. 2017). Colonies can vary greatly in size, ranging from a few individuals to hundreds or thousands, even within the same species. This variation may result from the patchy distribution of food and suitable breeding sites or the phenotypic sorting of individuals based on preferences for colonies of a particular size (Brown *et al*. 1990, Brown 2016).

In this study, we examined the characteristics of a colony of European Bee-eaters (*Merops apiaster*; hereafter bee-eaters), Common starlings (*Sturnus vulgaris*; hereafter starlings), and Common Swifts (*Apus apus*; hereafter swifts) in a loess bank located within the Protected habitat “Glinara”, Belgrade, Serbia. The bee-eater is a cavity-nesting species that excavates its nests, typically in loess, clay, or sand cliffs, within colonies ranging from a few to several hundred breeding pairs. Its nest consists of a burrow, including a tunnel and a nest chamber, with an average length of approximately 1.5 *m* (Bastian & Bastian 2024). As an excavator, the bee-eater is considered an ecosystem engineer, providing breeding sites for various cavity-adopting bird species, including starlings, swifts, Eurasian Hoopoes (*Upupa epops*), Great Tits (*Parus major*), Eurasian Tree Sparrows (*Passer montanus*), and House Sparrows (*Passer domesticus*), among others (Petrescu & Adam 2001, Purger 2001, Casas-Crivillé & Valera 2024, Shupova *et al*. 2022). Additionally, bee-eater burrows are used as shelters or breeding sites by various amphibians, reptiles, and mammals (Casas-Crivillé & Valera 2024).

The bee-eater is a long-distance migrant with a breeding range across Europe, Asia, the Mediterranean, and southern Africa, and non-breeding ranges in western, central, and southern Africa (Hahn *et al*. 2019, Bastian & Bastian 2024). Its population in Serbia is estimated at 5,200–8,500

breeding pairs, with an increasing long-term population trend (BirdLife International 2021a). The swift is also a long-distance migrant, breeding across the Palearctic and wintering in sub-Saharan Africa. It breeds in cavities, mainly within buildings, but also in nest boxes, tree holes, and rock crevices (Chantler *et al.* 2020). Its population in Serbia is estimated at 4,200–6,700 breeding pairs, with an increasing long-term population trend (BirdLife International 2021b). However, its breeding population is declining across Europe, where it is listed as a Near Threatened species (BirdLife International 2021b). Starlings breed in various types of existing cavities but can occasionally excavate their own holes in soft soil (Cabe 2020). They are widely distributed in Serbia, with an estimated population of 313,000–483,000 breeding pairs and a declining long-term population trend (BirdLife International 2021c). Recent research indicates that bee-eater nests located closer to the ground or the top of the bank are more susceptible to predation than those placed more centrally (Raković *et al*. 2024). Accordingly, the specific objectives of this study were: (1) to assess the number of active nests of bee-eaters, starlings, and swifts within the colony, and (2) to determine the positions of these nests relative to the ground and the top of the bank. Given the limited information on the breeding biology of bee-eaters, starlings, and swifts in Serbia, this study will likely enhance our understanding of these species and support future research and conservation efforts in the country.

MATERIAL AND METHODS

The study took place in the Protected habitat "Glinara", located in Višnjička Kosa, a suburban area of Belgrade, Serbia (44.8°N, 20.6°E), between April 10 and July 11, 2023. The study site features a diverse landscape, including a mix of agricultural and ruderal habitats, forests, thickets, hedgerows, and steep, exposed loess slopes formed by past clay excavation for nearby brickyards (Jakovljević *et al*. 2008) (Figure 1). Although no information on the establishment of the colony is available in the literature, it is assumed that birds colonized this area following the closure of the brickyards (Divac *et al*. 2023), which, based on Google Earth satellite imagery, likely occurred at the beginning of 2010s. The studied colony is located along a 550-meter-long bank with a height ranging from 2 to 8 meters. The 30-hectare area, including the studied bank, has been protected by the Law on Nature Protection as a site of local significance since 2024 (Official Gazette of the City of Belgrade 2024) (Figure 2).

To identify active nest holes, we recorded the colony using a high-definition digital camcorder from a distance of 50–60 *m*. Each segment of the colony was recorded for 15 minutes per session, multiple times during

the study period. The recorded material was observed on a computer screen several times to ensure the accuracy of the collected data. A nest was considered active if: 1) birds entered the hole two or more times over the course of the study period, or 2) birds entered the hole two or more times within a 15-minute observation session, often carrying insects in their beaks. To corroborate these observations, we inspected several nest holes using an endoscope camera, confirming the presence of adults with nestlings (Figure 3). Additionally, we photographed each section of the bank with a one- or three-meter scale, depending on the height of the bank segment.

Fig. 1. – The Protected habitat" Glinara" (photo: Srđan Marinčić).

For each nest, we determined the total bank height as the distance between the ground and the top of the bank using tpsDig2 software, version 2.32. We also calculated the nest position relative to the total bank height as the distance from the ground to the nest divided by the total height of the bank. The relative nest position was expressed as a percentage. Nests were then categorized into three height categories: bottom portion (relative nest position $\leq 1/3$ of the bank height), mid portion (relative nest position $> 1/3$ and $\leq 2/3$), and top portion (relative nest position $> 2/3$ of the bank height). Differences among species in nest distance from the top of the bank, and relative nest position, were analyzed using Welch's t-test, as Bartlett's test revealed heteroscedasticity ($p < 0.01$). Differences among species in the distances of nests from the ground were assessed using a standard t-test (McDonald 2014). To test for differences in the number of nests within height categories, we performed binomial tests for proportions for each species (Crawley 2013), with Bonferroni adjustments applied for pairwise comparisons (McDonald 2014). The nests of swifts were not included in analyses due to small sample size. All statistical analyses were conducted

in R version 4.4.0, using the stats package (R Development Core Team 2024).

Fig. 2. – Map illustrating the boundaries of the protected habitat "Glinara" (cyan line) and the location of the studied loess bank (yellow line).

RESULTS

During the 2023 breeding season, we recorded 305 active bee-eater nests, 127 starling nests, and 13 swift nests. The average distance (± SD; range) from the ground to the bee-eater nest hole was 3.25 *m* (± 1.40; 0.56–7.38), while the distance from the top of the bank to the nest hole was 1.78 *m* (± 1.22; 0.11–6.16). Bee-eaters placed significantly more nests in the top (N = 152) and mid portions of the bank (N = 124) compared to the bottom portion (N = 29; binomial tests: $p < 0.01$).

For starlings, the average distance from the ground to the nest hole was 3.70 *m* (± 1.40; 0.60–6.69), and the distance from the top of the bank to the nest hole was 1.78 *m* (± 0.90; 0.35–4.48). Starlings also placed significantly more nests in the top (N = 62) and mid portions of the bank (N = 63) compared to the bottom portion (N = 2; binomial tests: $p < 0.01$). The distance from the ground to the nest hole was significantly different between bee-eaters and starlings ($t = -3.02$, $df = 234.46$, $p < 0.01$). However, there were no significant differences in the distance from the top of the bank to the nest hole ($t = -0.002$, $df = 314.71$, $p = 1.00$) or in the relative position of nests ($t = -1.01$, $df = 295.30$, $p = 0.31$) between these two species.

For swifts, the average distance from the ground to the nest hole was 4.19 *m* (± 1.44; 1.43–6.35), and the distance from the top of the bank to the nest hole was 2.04 *m* (± 1.44; 0.51–6.50). Seven swift nests were placed in the top portion of the bank, six in the mid portion, and none in the bottom portion of the bank. Two burrows used by starlings at the beginning of May were subsequently occupied by bee-eaters. Similarly, two nests initially occupied by starlings were later used by swifts as the breeding season progressed.

DISCUSSION

We found that the colony within the Protected habitat “Glinara” comprises over 300 active bee-eater nests, making it the largest bee-eater colony in Serbia. The highest number of bee-eaters breeds in Vojvodina, which accounts for 60% of the breeding population in the country (Puzović *et al*. 2015). High numbers of bee-eaters have been recorded at Titelski Breg, with an estimated 400–700 breeding pairs, and along the Danube loess bluffs (eastern Srem), with an estimated 200–400 breeding pairs (Puzović *et al*. 2009). However, at Titelski Breg, bee-eaters breed in dozens of scattered colonies, none exceeding 100 breeding pairs (D. Radišić, pers. comm.). Additionally, the sizes of these colonies, including those in the

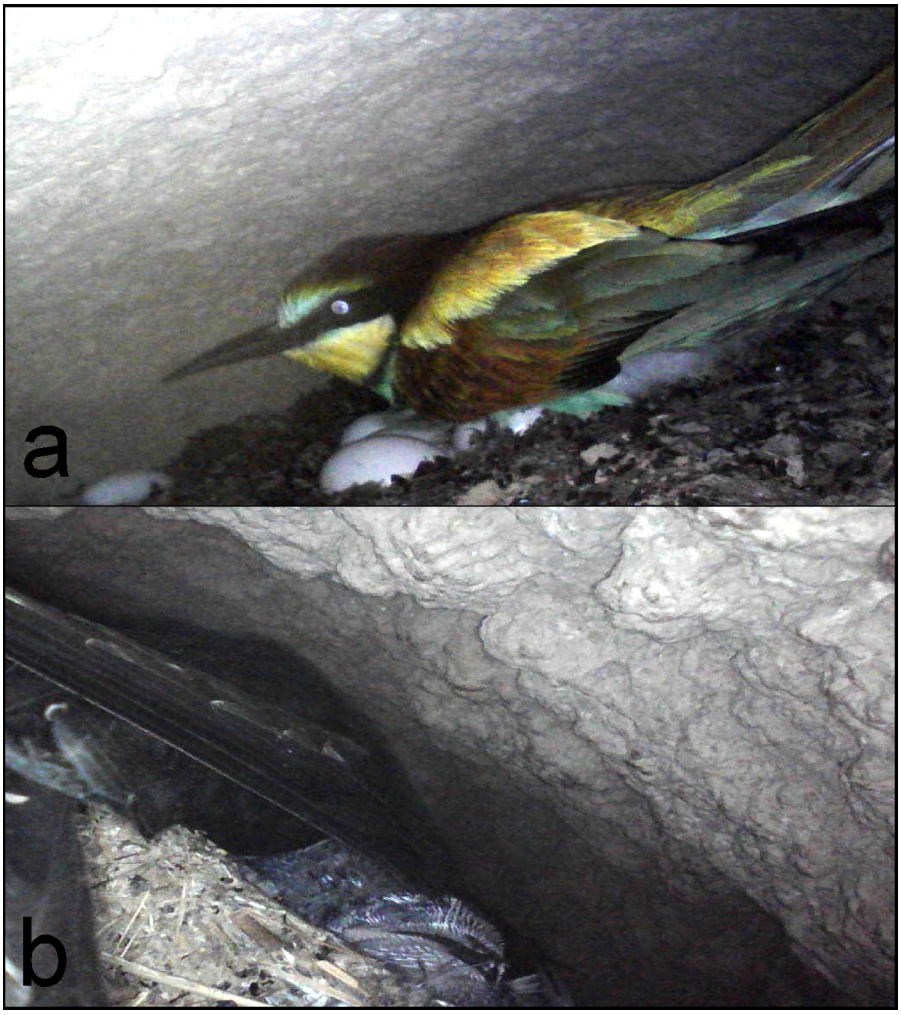

Fig. 3. – The burrows recorded by an endoscope camera showing (a) a bee-eater laying on eggs, and (b) a swift with nestlings.

Deliblato Sands, were estimated by counting the number of adult individuals (D. Radišić, pers. comm.), a method that typically overestimates colony size (Mere 2008). By video-recording the colony in Višnjička Kosa, we provided accurate estimates of its size, showing that it contains a high number of active nests within a considerably smaller area compared to other colonies in the country, including those in Titelski Breg, the Danube loess bluffs, and the Deliblato Sands (Puzović *et al*. 2015, Šćiban *et al*. 2015). This density likely makes the Višnjička Kosa colony the most densely populated bee-eater colony in Serbia. Moreover, the broader area of Višnjička Kosa, extending beyond the boundaries of the protected area,

contains additional loess banks that support breeding pairs of bee-eaters not included in this study. Accordingly, this entire area represents an important breeding site for this species in the country.

By digging their burrows, bee-eaters provide breeding sites for starlings and swifts, with the former being particularly abundant. Both species were observed flying into the nest holes at the end of April, confirming their breeding activity. During this period, bee-eaters had just begun arriving at the colony, with their numbers progressively increasing by mid-May. The early arrival of swifts from their wintering grounds, along with the year-round presence of starlings, likely gives these species a competitive advantage in occupying suitable burrows before the bee-eaters appear. The use of bee-eater burrows by these two species has been previously documented. For example, Purger (2001) and Petrescu and Adam (2001) reported their co-occurrence in Vojvodina and Romania, respectively, where other bird species, particularly tree sparrows, often occupied empty bee-eater nests.

Although starling nests were positioned higher above the ground compared to bee-eater burrows, all three species avoided breeding in the bottom portion of the bank. In newly established colonies, bee-eaters tend to dig burrows just below the top of the hill, whereas nests are added to lower portions of the banks in re-used colonies (Bastian & Bastian 2024). Nest placement near the cliff top may reduce disturbances from neighboring birds digging their own nests. Additionally, birds are less prone to predation during nest construction by mammals approaching from the ground (Petrescu 1998). However, nests located near the top of a bank are more susceptible to predation by mammals that can easily excavate them from above (Bastian & Bastian 2024). Furthermore, nests closer to both the top and bottom of cliffs are more vulnerable to predation by the Caspian Whipsnake (*Dolichophis caspius*), as demonstrated for this colony (Raković *et al*. 2024). Thus, the positioning of bee-eaters nests within the vertical bank surface may be influenced by factors other than predation. As cavity adopters, starlings and swifts are limited by the availability of existing burrows excavated by bee-eaters. Consequently, these birds placed their nests in the mid and upper portions of the bank, where cavities were most abundant. Additionally, swifts may be restricted to the higher portions of the bank due to the minimum height required for successful take-off.

The study area has been protected as a site of local significance due to its role as a habitat for protected and endangered species of animals and plants (Divac *et al*. 2023). An additional value of the area lies in its proximity to the country's largest metropolitan center, providing the public with opportunities for biodiversity education and conservation awareness. This study represents the first comprehensive description of the protected

mixed-species bird colony, providing a potential foundation for future research and contributing to efforts in conservation and management planning.

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КАРАКТЕРИСТИКЕ МЕШОВИТЕ КОЛОНИЈЕ ПЧЕЛАРИЦА, ЧВОРАКА И ЦРНИХ ЧИОПА НА ПОДРУЧЈУ ЗАШТИЋЕНОГ СТАНИШТА „ГЛИНАРА“, БЕОГРАД, СРБИЈА

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РЕЗИМЕ

У раду смо описали карактеристике мешовите колоније пчеларице (*Merops apiaster*), чворка (*Sturnus vulgaris*) и црних чиопа (*Apus apus*) на подручју Заштићеног станишта „Глинара“, на Вишњичкој коси у Београду. Подручје је од 2024. године Одлуком скупштине Града Београда заштићено као подручје III категорије, односно заштићено подручје локалног значаја. Истраживана колонија је смештена у 550 *m* дугом лесном одсеку, који је настао ископавањем земљишта за оближњу фабрику цигала. Ради пребројавања активних гнезда током сезоне гнежђења 2023. године, колонија је снимана камером у периоду од маја до јула. Сваки сегмент одсека је сниман неколико пута у трајању од по 15 минута. Прегледањем видео материјала, установили смо да се колонија састојала од 305 активних гнезда пчеларица, 127 гнезда чворака и 13 гнезда црних чиопа. Просечно растојање од тла до отвора гнезда пчеларица износило је 3,25 *m*, док је просечно растојање од врха одсека до отвора гнезда износило 1,78 *m*. Просечно растојање од тла до отвора гнезда чворака износило је 3,70 *m*, а просечно растојање од врха одсека је такође износило 1,78 *m*. Гнезда црних чиопа су у просеку од тла била удаљена 4,19 *m*, а од врха одсека 2,04 *m*. Значајно више гнезда пчеларица и чворака је било у горњем и

средњем делу одсека у односу на доњи део, док црне чиопе ниједно гнездо нису имале у доњем делу одсека. Колонија у Заштићеном станишту „Глинара“ је једна од највећих колонија пчеларица у Србији. Подаци изнети у раду представљају први детаљан опис мешовите колоније птица у овом заштићеном станишту, те могу послужити као основ за будуће планове управљања и заштите подручја које у свом саставу укључује ове врсте као гнездарице. Уједно, наведена методологија утврђивања величине популације гнездарица у мешовитим колонијама је први пут примењена у Србији и показала је висок ниво прецизности у дефинисању величине популација гнездећих парова.